STABILISED

GRAVEL FOR ROAD SUB-BASE:

A LABORATORY STUDY

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GRAVEL FOR ROAD SUB-BASE:
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Under the guidance of
Prof. Mahabir Panda

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CERTIFICATE

This to certify that the thesis entitled "**Stabilised Gravel for Road Sub-base: A Laboratory Study"** submitted by **Manoj Kumar Behera** bearing roll no. **213CE3081** in partial fulfilment of the requirements for the award of **Master of Technology** in **Civil Engineering** with specialization in "**Transportation Engineering"** during 2013-2015 session at the National Institute of Technology, Rourkela is an authentic work carried out by her under my supervision and guidance. To the best of my knowledge, the results contained in this thesis have not been submitted to any other University or Institute for the award of any degree or diploma.

Date :-
Place: Rourkela

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Dedicated to

All the people

Endeavouring for the welfare

Of our country

At each and every moments of their lives

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ABSTRACT

High quality aggregates that meet the specifications are getting increasingly scarce and expensive in many localities in India. Traditional flexible pavement specifications require high quality aggregates in both base and sub base course. In many cases locally available aggregates are not satisfying the specifications and the aggregates that meet the specifications have to be hauled in long distances. This act significantly increases the cost associated with the construction and subsequent maintenance and rehabilitation of them. Thus, the use of locally available marginal aggregates in flexible pavement construction is one of the possible answers to high pavement construction costs and lack of quality aggregates sources in a vast country like India. A broad definition of a marginal aggregate is “any aggregate not in fully accordance with the specifications used in a country for normal road aggregates but can be used successfully either in special conditions, made possible because of climatic characteristics or recent progress in road techniques or after subjecting to particular treatment”. So if through appropriate modification of the materials or structural design the use of local materials can be permitted, the construction can be accelerated and significant monetary benefits can be achieved.

So the main objective of the study is to improve the properties of the locally available gravel soil/ marginal aggregate (Moorum) by adding cement and bitumen emulsion. An attempt has been made to use cement for increasing the strength of the gravel and emulsion for increasing the water resisting capacity. The whole work involves increasing strength of gravel soil (Moorum) and expressed in terms of CBR and UCS value.

Key words: - Marginal aggregate, CBR, UCS, Bitumen Emulsion

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Abbreviations

U.C.S	Unconfined Compressive Strength
C. B.R.	California Bearing Ratio
O. M.C.	Optimum Moisture Content
M. D.D.	Maximum Dry Density
P. L.	Plastic Limit
L. L.	Liquid Limit
P. I.	Plasticity Index
SS	Slow Setting
MS	Medium Setting
RS	Rapid Setting
OPC	Ordinary Portland Cement
MORT&H	Ministry of Road Transport and Highways
IS	Indian Standard
ASTM	American Society for Testing Materials
M	Meter
mm	Millimeter
kN	Kilo Newton

cm	Centimeter
kg	Kilogram
g	Gram
sec	Second

Chapter I
Introduction

1.1 Background

High quality aggregates are becoming increasingly scarce and expensive in many localities. Traditional flexible pavement specifications require high quality aggregates in the flexible pavement base course materials and asphalt concrete mixtures. In an increasing number of cases, locally available aggregates are not meeting applicable specifications, and aggregates that meet the specifications must be imported to the site at considerable expense.

The use of marginal aggregates in flexible pavement construction is one of the best answers to high pavement construction costs and a lack of quality aggregate sources. A broad definition of a marginal aggregate is "any aggregate that is not normally usable because it does not have the characteristics required by the specification, but could be used successfully by modifying normal pavement design and construction procedures"'.*(Source:-Marginal aggreagtes in flexible pavement : Background survey and experimental plan, Final report U.S. Department of Transportation Federal Aviation Administration, 1994)*

Using local available marginal materials is often very tempting, but the decision to use or reject these materials should only be made after a complete evaluation. The decision should be based on an evaluation of the material characteristics and how these characteristics will affect the design, performance, and construction of the pavement. Potential problem areas must be clearly identified, or any expected cost savings will be lost. *(Source:-Marginal aggreagtes in flexible pavement : Background survey and experimental plan, Final report U.S. Department of Transportation Federal Aviation Administration, 1994)*

This study will attempt to define in engineering terms the impact of using marginal aggregates in flexible pavements. Strategies for improving the performance of marginal aggregates to equal that of standard aggregates will be evaluated. The major emphasis will be on marginal aggregates for flexible pavements.

1.2 Need for present research

In order to decide whether to use marginal materials in both advantages and disadvantages should be weighed. This is not simple judgement since some aspects involved can't be quantified in monetary terms. An evaluation of marginal materials for use should be based on technical. Economical and environmental factor, and due consideration should be given to them. *(Source:-Enabling use of marginal aggregates in road construction, Manuel C.M. Nunes, University of Nottingham, 1994)*

- Availability and economic acceptability: - marginal materials need to be available in adequate quantities and at convenient locations (or to be economically transported to the sites) to justify the development.
- Technical adequacy: - suitable physical, mechanical and chemical properties are required in order to maintain appropriate standard of quality and performance in road construction.
- Environmental acceptability: - all the materials used in pavement must not be potentially harmful during the construction and throughout the life time of the pavement.

  (Source:-Enabling use of marginal aggregates in road construction, Manuel C.M. Nunes, University of Nottingham, 1994)

The use of marginal materials in sub base and road base level represents a value added application compared with their frequent waste nature that may represent an important contribution in making these aggregates competitive against conventional materials and reduce the importance of hauling cost over long distances. For this purpose some of the stabilisation may be necessary to improve their performance. *(Source:-Enabling use of marginal aggregates in road construction, Manuel C.M. Nunes, University of Nottingham, 1994)*

1.3 Objective and scope of work

This research focussed essentially on the lacunae discussed above. The overall aim is to develop a stabilised gravel to enable the use of marginal aggregates in road construction.

Moorum

Gravels

Laterite

Shales

(Source: - U.K. Guru Vittal (Use of Marginal Materials and Fly ash in Road Works))

Figure 1.1:- Different types of Marginal Aggregates available in India

Out of different marginal aggregates found in India, the marginal aggregates used in this study is Moorum which is a fragmented weathered rock naturally occurring with varying proportions of silt and clay. It is considered as a low grade marginal material for road construction. It is widely available in different parts of our country with significant variation in its qualities from one location to another in terms of its crushing and impact value, grain size, clay and deleterious content. It has generally low bearing capacity and high water absorption value in comparison to conventional aggregates. It finds application in the construction of base/sub base course in rural roads of India with suitable stabilization methods. Moorum is a locally available marginal aggregates widely present in different parts of our country. It has less productive use as compared to other marginal aggregates. So the purpose of this research is to utilize moorum by focusing on the following features.

- To enable the most appropriate use of moorum in pavement construction (in base/sub base course) by ensuring adequate performance result in the field of strength and shear value.
- To study the characterization of moorum using cement and bitumen emulsion as additives.

1.4 Importance and benefits

The main benefits from this study are expected to be twofold. First of all this result will contribute to broaden the existing knowledge in the field of marginal aggregates, especially concerning their laboratory performance under C.B.R. and U.C.S. test. In due course, this knowledge should contribute to future changes in the Indian specifications for rural road construction and as a result it will likely to widen the market for marginal aggregates. *(Source:-Enabling use of marginal aggregates in road construction, Manuel C.M. Nunes, University of Nottingham, 1994)*

Secondly, from a more general use of materials further benefits will result, such as

- ✓ The reduction of demand for conventional aggregates, allowing preservation of finite resources.

- ✓ The reduction of energy cost related to extraction and transportation of conventional aggregates.
- ✓ The reduction in environmental cost related to conventional aggregates quarrying.
- ✓ The reduction in environmental and economic problem associated with waste storage and dumping.
- ✓ Conservation of conventional aggregates by releasing land that would otherwise be used for quarrying aggregates.

(Source:-Enabling use of marginal aggregates in road construction, Manuel C.M. Nunes, University of Nottingham, 1994)

1.4 Organizations of the Thesis

The thesis has been presented as per following chapters.

- ❖ Chapter-I, general information about the interface about the background of marginal aggregates and objectives of the present study is described.
- ❖ Chapter-II, a brief review of the recent past studies carried out in laboratories to evaluation of various properties of marginal aggregates.
- ❖ Chapter-III, described the experimental methodology carried out in this study for observing the strength of marginal aggregates.
- ❖ Chapter-IV, analyzed the results and discussion about the experimental Investigations.
- ❖ Finally in Chapter-V a summary of the present study and the major conclusions are explained here with recommendation for future work

Chapter II
Review of Literature

2.1 Introduction

This chapter focused on an extensive literature review on some field and laboratory studies that were conducted in the recent past to observe efficiency of marginal aggregates to use in base/sub-base course of roads. It also elaborates different stabiliser for improving the strength of marginal aggregates.

2.2 Past Studies on Different Marginal Aggregates and different Stabiliser for improving its Strength

Evans and Hicks (1982) tried excellent basalt, two low quality marine basalts, and a fine grained hill sand. The blend properties assessed which incorporate dia. metral versatile modulus and a dia. metral weakness life for both as compacted example and example moulded by dampness introduction. Layered versatile outline standard were utilized with the dynamic test results to create layer equivalencies for emulsion treated negligible total contrasted and hot blend black-top cement. The outcomes show that that beneficiation of minor total with black-top emulsion ought to make satisfactory clearing quiets, especially for low volume streets.

Al-Abdul Wahab and Asi (1997) utilized moderate setting emulsified black-top and medium curing lessening black-top to settle both marl and rise sand. Lime and Portland bond (2% and 4%) were added to the settled soils to quicken the curing procedure and to lessen strength misfortune because of water harm. It was found that balanced out operators enhanced both shear quality and imperviousness to the broke down soils to water harm. It was watched that Portland concrete was more compelling than lime.

Asi et al. (1999) completed test to explore the practical utilization of frothed black-top innovation in Saudi Arabia to enhance the common ridge sands for conceivable use as a base or sub base material. A few variables were explored to assess the relative change of ridge sand and to allow the improvement of outline methodology for the future utilization of frothed black-top innovation in the cruel climatic states of eastern Saudi Arabia. Measurable examination of the outcomes was utilized to confirm the impacts of emulsified black-top and frothed black-top treatment, with and without the expansion of Portland concrete, on the quality attributes of the treated blends, top blends, when contrasted with that of the emulsified black-top blends.

Nageim et al. (2012) led different tests which went for growing new icy bituminous emulsion blends (CBEM) containing fly slag from burned residential and mechanical by-items contrasted and those after effects of customary control frosty containing OPC and hot blend black-top. The principle targets of the analyses were to examine the change in mechanical properties of CBEM‟s because of consolidating OPC, and recognize the likelihood of supplanting the OPC with waste fly fiery remains materials. The blends mechanical properties explored were; ITSM, creep firmness. Toughness in term of water affectability was examined as well.

Khadijeh Moosavi, Behzad Kalantari (2011) directed examinations to enhance bearing limit of wind-blown sand. The change in the mechanical quality of settled examples was contemplated by California Bearing Ratio (CBR) test. The curing period utilized are 7, and 28 days for both, un-drenched and splashed specimens. The got results demonstrate that CBR estimations of windblown sand treated with concrete fundamentally increments by rate of bond increments. Imperviousness to disappointment because of forced heaps of this kind of sand treated with concrete increments with time. 1%, 3%, 5%, 7%, 9%, 11%, and 13% of the mounts of concrete was added to the dirt and it was turned out to be clear that if under (100 kg/m^3) of customary bond Portland is blended with wind-blown sand and compacted at their ideal dampness content, following 28 days of curing expand the CBR of in-situ wind-passed up more than 23 folds (from 7.2% to 172%) for un doused examples,

Brown and Needham (2000) measured the rate at which mixture of bitumen beads created and stuck to the total particles, since this is the beginning instrument by which mechanical properties of the blend are produced. The study was then stretched out to get a comprehension of the properties of emulsion mixed with OPC, hydrated lime or limestone filler. This was done since it was felt that a commitment to "tying" of the total in blends originated from the hydration of bond and from the blended bitumen. Element Shear Rheometer tests were utilized on different mixes exhibiting the solidifying impacts of both OPC and hydrated lime and that filler had little impact. The emulsifying procedure was additionally indicated to have no impact on the qualities of the base bitumen. Electron microscopy was utilized to study the crystalline structures of completely cured blends with and without OPC expansion. Master translation considered that a percentage of the qualities of concrete hydration impacts were available in those blends consolidating OPC. The study inferred that the enhancements to key properties of icy blend by the expansion of OPC can be clarified by a scope of components, including enhanced rate of emulsion mixture after compaction, concrete hydration and upgrade of cover thickness.

Yan et al. (2010) decided the weakness properties of black-top emulsion and froth black-top frosty reused blends utilizing the Nottingham Asphalt Tester (NAT) (Cooper NU-14 analyzer). In this examination, froth and emulsion cool reused blends were assessed for backhanded rigidity, firmness modulus at three temperatures and four anxiety levels, and exhaustion life at 15 _C and four anxiety levels. Furthermore, the law of dislodging and split improvement were additionally investigated amid the exhaustion testing. The outcomes demonstrated that solidness modulus diminished with expanding temperatures and anxiety levels. Through circuitous tractable

Mofreh F. Saleh (2007) made an expense examination activity looking at the capital expense of eight base course adjustment choices notwithstanding hot blend black-top (HMA). Bond, lime and froth bitumen adjustment versus HMA plan options were analyzed. The froth settled blend speaks to a great base course material balanced out with 2.0% concrete and 3.5% froth bitumen. The consequences of this examination demonstrated that froth bitumen adjustment utilizing excellent totals and around 2% bond is aggressive contrasted with unbound materials in light of the fact that a diminished layer thickness is needed.

Sariosseiri and Muhunthan (2009) investigated the utilization of Portland bond in the adjustment and adjustment of soils in the condition of Washington, USA. Concrete was included rates of 2.5, 5, 7.5, and 10%, by dry weight of the dirts. Research facility tests to focus the drying rate of the dirt, Atterberg limits, compaction attributes, unconfined compressive quality, and united un depleted tri hub conduct were performed. Aftereffects of the examination indicated huge change in drying rate, workability, unconfined compressive quality, and shear quality.

Niazi and Jalili (2009) utilized Portland concrete and lime as added substances in Cold In-Place Recycling (CIR) blends. The Portland concrete was presented in powder shape and lime used as hydrated lime in powder frame and lime slurry, and the impacts of every added substance on properties of CIR blends has been assessed. The outcomes demonstrated that both lime and Portland concrete can build Marshall Stability, flexible modulus, rigidity, imperviousness to dampness harm and imperviousness to changeless misshapening of CIR blends. Utilization of Portland concrete and lime slurry would be advised to results than hydrated lime however because of the challenges in creating lime slurry by and by, the utilization of Portland bond is prescribed.

Zhao et al. (1998) probed a three-stage bond black-top emulsion composite (CAEC), in which black-top was presented as a pad layer in the middle of coarse totals and concrete mortar network by scattering black-top emulsion-covered coarse totals into concrete mortar framework. Lab tests on exhaustion, quality, unbending nature, temperature powerlessness, and anxiety strain relationship were actualized to assess the mechanical properties of the CAEC. The preparatory test outcomes demonstrated that CAEC had the greater part of the qualities of both bond and black-top, specifically the more extended exhaustion life and lower temperature powerlessness of concrete cement, and higher sturdiness and adaptability of black-top cement.

Cha vez -Valencia et al. (2007) included polyvinyl acetic acid derivation emulsion (PVAC-E) was added to a cationic brisk set emulsified black-top to get an altered black-top emulsion that was blended with a neighbourhood total keeping in mind the end goal to set up two sorts of CMA. In the sort I blend, totals were covered by a film of asphalt–polyvinyl acetic acid derivation (A–PVAC) folio. In the sort II blend, before the A–PVAC folio was layered, the total was secured with the polymer by blending the total in a weakened PVAC-E. Since the small scale particles of the polyvinyl acetic acid derivation were all around scattered in the black-top clearing blend lattice for changed CMA sort II, the compressive qualities of test examples were enhanced by 31% contrasted with the qualities acquired with the unmodified

Pereza et al. (2013) explored the mechanical properties of in situ materials with bitumen emulsion. A portrayal is given of the sorts of materials that are settled with bitumen emulsion shortly accessible and diverse theories about their conduct and distinctive properties are set forth. The two primary classifications of mechanical properties researched in the research facility by method for mechanical test are tended to: (a) properties like those of granular materials as per their anxiety subordinate conduct and (b) properties taking after hot blend black-top materials as per their temperature and time-subordinate thick versatile conduct.

Liebenberg and Visser (2004) tested to give some knowledge into the conduct of emulsion-treated materials which has prompted the improvement of interval exchange works that may be utilized as a part of a robotic examination. Emulsion-treated materials act in two stages, a pre cracked and post broke stage. In the pre cracked stage, the material has a firmness that is like that of gently solidified material, while in the post-split stage it has a solidness that is practically identical to that of the untreated material.

Ahlrich and Rollings (1993) assessed the usage of substandard or negligible totals in adaptable asphalt development of air terminal asphalts. This examination was embraced to assess the impacts of utilizing lower quality totals, for example, adjusted uncrushed rock and sands on the rutting of adaptable asphalts. The extent of this exploration study incorporated a survey of accessible writing and existing information (Phase I), a lab assessment composed to focus the impacts of minor totals and potential procedures to redesign these substandard materials (Phase II), and a field assessment including test areas using the most encouraging methods.

Pinard and Obika (1997) plot the outline and development points of interest of reviewed total bituminous seals in light of broad experience of this kind of surfacing in Southern and Eastern Africa. Specific consideration is paid to the properties and qualities of the totals and bituminous fasteners utilized as a part of the development of the seal in connection to its execution and expense adequacy. The paper infers that the utilization of evaluated total seals empower more broad utilization to be made of normally happening, frequently peripheral quality, and materials contrasted with the more ordinary bituminous surface medicines. In positive circumstances, the utilization of these seals can make a noteworthy commitment to the monetary reasonability of up-evaluating rock streets or developing, amazing failure volume streets to bitumen surfaced standard, especially in the remote ranges of creating nations.

Yuan and Nazarian (2010) treated negligible totals with calcium-based added substances (predominantly concrete and lime) and/or their degrees were changed to enhance their quality. Tri pivotal pressure test and unconfined pressure test was likewise directed.

Choudhary et al. (2012) introduced the blend outline of icy blends for utilization in distinctive courses of asphalts. They additionally gave data on the diverse added substances which are generally used to build the execution of cool blend. It additionally gives the aftereffects of same prior studies on frosty blends. It additionally highlights the extent of utilizing chilly blend as a part of provincial street development in North Eastern conditions of India.

Ransinchung et al. (2014) concentrated on the suitability of utilizing moorum and neighbourhood Ganga sand by part supplanting the stone dust extent of routine Wet Mix Macadam (WMM) blend. Furthermore, conventional Portland bond was utilized as stabilizer with moorum as a part of extents changing from 3% to 9% to study its suitability as WMM layer. A sum of seven WMM blend extents were viewed as including the traditional blend and different tests were directed on these.

Mishra and Rath (2011) explored the building properties of just soil, soil + fly powder @ (20, 30, and 40 %), soil + lime @ (2, 3, and 4 %) & soil + fly slag @ (20, 30 %) + lime @ (2, 3, 4%) was figured out to be utilized as sub-evaluation material. All the blends were arranged by weight. For the sub-base layer it was endeavoured to supplant the sand in the customary 70:30 blend of moorum & sand, with fly fiery debris. For this tests were completed on blends of moorum, sand (0, 15, and 30%), fly fiery remains (15, 30%) alongside lime (0, 3%). For the above referred to mixes of the materials for the sub-level & sub-base the vital exploratory examination like standard delegate compaction test, consistency limits, molecule size dissemination tests were led before doing CBR test .For all the blends CBR moulds were give at OMC a role according to standard delegate compaction (as fancied for low volume street development), for 4 days splashed condition.

Patil and Patil(2013) tried different properties of sub evaluation soil by utilizing soil stabilizer and generally accessible poor materials. The added substance like RBI Grade 81is used to enhance the properties of sub evaluation soil. The CBR estimation of sub level soil can be enhanced by utilizing moorum with RBI Grade 81and expense of development can be diminished to certain degree. From CBR test, it is found that the splashed CBR estimation of soil is enhanced by 476.56% i.e. 2.56% to 14.76% by settling soil with 20% moorum and 4% RBI Grade 81. The different blends of soil: moorum: RBI Grade 81 for the distinctive extents were tried for greatest dry thickness (MDD), ideal dampness content (OMC) and splashed CBR esteem.

Paul et al. (2011) proposed a prologue to soil adjustment in asphalt taking a blend of bitumen and all around reviewed rock or squashed total. After compaction it gave an exceedingly enduring waterproof mass of sub base or base course quality. The essential framework included in black-top adjustment of fine-grained soils is a waterproofing marvel. Soil particles or soil agglomerates were secured with black-top that prevents or sub sides the passageway of water which could frequently realize reduction in soil quality. Likewise, black-top adjustment can improve sturdiness qualities by making the dirt impenetrable to the un-favourable effects of water, for instance, volume. In non-press materials, for instance, sands and rock, beat rock, and crushed stone, two central frameworks are element: waterproofing and attachment. The black-top covering on the union less material gives a film which suspects or impedes the passageway of water; in this manner lessening the slant of the material to lose quality in the region of water. The second instrument had been recognized as bond and attributes of gravelly soils.

L. Lauren (2011) performed a test take a shot at soil adjustment items like the polymer emulsion for having all the reserves of being the adjustment agents for what's to come. Each one of the three polymer-emulsions was used as a piece of this testing task performed famously making strong samples that all gave suitable CBR qualities to ways. The CBR test was used for this endeavour in light of the fact that it has been viably related with quality capacity of the sub level, sub base, and base course material for usage in road and runway advancement.

Nikraz (2012) dealt with Bitumen-concrete Stabilized Layer in Pavement Construction Using Indirect Tensile Strength (ITS) Method. In this study, the objective was to blend and mix Portland cement and bitumen emulsion with soil for redesigning the quality, quality and sturdiness of the earth. In order to redesign the dirt quality and lessening its shortcoming to water, soil adjustment is obliged to be associated with the dirt. As per this, improved weight trade was added to the black-top foundation by having the bond sway which truly underpins the immovability and Bitumen emulsion sways which upgrade flexibility and soil vulnerability of the settled layer.

Marandi and Safapour (2012) chipped away at Base Course Modification through Stabilization utilizing bond and bitumen. The primary goal of this exploration was to dissect the utilization of bitumen emulsion in base course adjustment. Adjustment of soils and totals with bitumen reveals to it varies enormously from bond adjustment. The essential instrument included in bitumen adjustment was a waterproofing marvel.

Bondietti et al. (2014) analyzed the impact of bitumen emulsion and concrete adjustment on UCS and ITS. They likewise inspected the impact of curing and further present in-situ solidness results got from diversion testing. Anxiety related conduct had likewise been investigated through element tri hub testing. UCS and ITS results had been utilized to plot a novel configuration chart for every material, giving UCS as an element of rate bitumen and rate concrete. The configuration chart can be utilized to interject for different qualities with constrained beginning testing to build up obliged bitumen and concrete proportions to get a focused on UCS. Results for the two materials demonstrated a straight relationship in the middle of UCS and ITS and the pertinence of doing the I.T.S. is addressed. Significant picks up in UCS and I.T.S. were seen more than 28 days and these did not associate with acknowledged quickened curing systems.

2.3 Critical Reviews

- In the above studies it reveals that strength of marginal aggregates can be increased by adding different types of additives which can later be used as sub base/ base course of roads.
- Very few studies were aimed at the use of emulsion with any calcium based additives like cement or lime for improving the quality of marginal aggregates.
- Therefore, there is a scope towards the use of both emulsion and cement in stabilization of locally available marginal aggregate Moorum.

2.4 Methodology

Methodology to be followed during the course of experimental work is as follows.

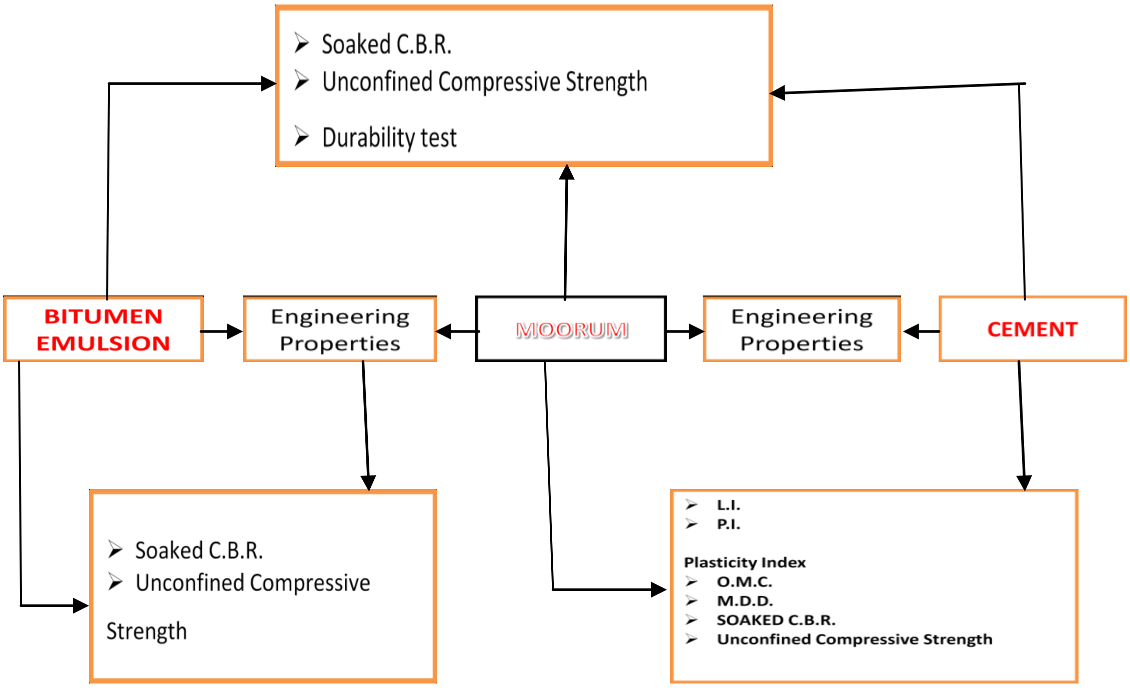


Figure 2.1:- Methodology flow chart

Chapter III
Experimental Methodology

3.1 Introduction

This chapter describes the experimental works carried out in this present investigation. This chapter is divided into two parts. First part deals with the Materials used second part deals with the tests carried out on the mixture.

3.2 Materials Used

3.2.1 Moorum

The primary material used in this study is Moorum which is collected from NIT, Rourkela campus. Moorum which is a fragmented weathered rock naturally occurring with varying proportions of silt and clay. It is considered as a low grade marginal material for road construction. It is widely available in different parts of our country with significant variation in its qualities from one location to another in terms of its crushing and impact value, grain size, clay and deleterious content. It has generally low bearing capacity and high water absorption value in comparison to conventional aggregates. It finds application in the construction of base/sub base course in rural roads of India with suitable stabilization methods. *(Source: - Laboratory evaluation for the use of moorum and ganga sand in wet mix macadam unbound base course, Vol. No 42 No. 4 April 2014, Indian Highways)*

3.2.2 Bitumen Emulsion

Emulsified Bitumen normally comprises of bitumen beads suspended in water. Most emulsions are utilized for surface medications. On account of low consistency of the Emulsion when contrasted with hot connected Bitumen, The Emulsion has a decent entrance and spreading limit. The kind of emulsifying specialists utilized as a part of the bituminous emulsion figures out if the emulsion will be anionic or cationic. In the event of cationic emulsions there are bituminous beads which convey a positive charge and Anionic emulsions have contrarily charged bituminous drop. *(Source: - www.fultonhogan.com)*

In light of their setting rate or setting time, which shows how rapidly the water isolates from the emulsion or settle down, both anionic and cationic emulsions are further characterized into three unique sorts. Those are fast setting (RS), medium setting (MS), and moderate setting (SS). Among them fast setting emulsion is exceptionally unsafe to work with as there is next to no time stays before setting. The setting time of MS emulsion is almost 6 hours. In this way, work with medium setting emulsion is simple and there is adequate time to place the material in legitimate place before setting. The setting rate is fundamentally controlled by the sort and measure of the emulsifying operators. The chief distinction in the middle of anionic and cationic emulsions is that the cationic emulsion surrenders water speedier than the anionic emulsion.

More than a period of time, which may of years, the black-top stage will over the long haul separate from the water. Black-top is insoluble in water, and breakdown of the emulsion incorporates the mix of drops. The black-top drops in the emulsion have a little charge. The wellspring of the charge is the emulsifier, and ionisable portions in the black-top itself. However when two beads do achieve enough essentialness to annihilation this obstruction and approach about then they hold quick to each other. More than a period of time, the water layer between beads in floccules will thin and the drops will join. Segments which compel the drops together, for instance, settlement under gravity, dispersal of the water, shear or hardening will stimulate the flocculation and blend process. For this situation blending with soil medium setting bitumen emulsion is less successful and quick setting is not simple to work with soil. So here I utilize moderate setting emulsion as primary settling operators. *(Source: - www.fultonhogan.com)*

Today the primary usage of bitumen is in the asphalt business for development and upkeep. Bitumen emulsions are a scrambling of bitumen in a watery nonstop stage, settled by the extension of an emulsifier. They are prepared as emulsions at high temperatures, however associated as powerful scatterings at including temperatures. In asphalt designing bitumen things are ordinarily included with total. The strong grip that happens between the bitumen and mineral total enables the bitumen to go about as a cover, with the mineral total giving mechanical quality to the way. From the audit of present situation bitumen emulsion goes about as a key device for predominantly for street upkeep and development. Anyway, adequately here emulsion is going to use as a dirt settling operators.

3.2.3 Cement

Types of cement used here is O.P.C. (Ordinary Portland Cement) grade 43. O.P.C. 43 grades based on the 28 days compressive strength of cement. Different types of ordinary Portland cement available in India like grade 33, grade 43 and grade 53. That all based on their 28 days characteristics strength. Type of cement used in this research is 43 grades OPC.

3.3 Tests carried out on the Materials used and their Mixtures

3.3.1 Specific Gravity

The proportion between the mass of any substance of an unequivocal volume partitioned by mass of equivalent volume of water is characterized as Specific Gravity. For soils, it is the quantity of times the dirt solids are heavier in the appraisal to the equivalent volume of water present. So it is fundamentally the quantity of times that dirt is heavier than water. Particular gravities for distinctive sort of soils are not same. In the season of investigation it ought to be thought about the temperature rectification and water ought to be without gas refined water. This particular gravity of soil is indicated by 'G'. Particular gravity is extremely an essential physical property used to figure other soil designing properties like void proportion, thickness, and porosity and immersion condition.

As it is talked about, the proportion between the heaviness of the dirt solids and weight of an equivalent volume of water is termed as Specific Gravity. The estimation is done in a volumetric jar in a test setup where the volume of the dirt is figured out and its weight is then further separated by the heaviness of equivalent volume of water. G is specific gravity

$$G = (M2 - M_1) - ((M_4 - M_1) - (M_3 - M_2))$$

M_1 = Weight of bottle

M_2 = Weight of bottle and dry soil

M_3 = Weight of bottle, dry soil and water

M_4 = Weight of bottle and water

Specific gravities for different soil are not same generally, the general range for specific gravity of soil can be categorized are:

Table 3.1: Standard Specific Gravity

Types of Soil	Specific Gravity
Sand	2.63 – 2.67
Silt	2.65 – 2.70
Clay and silt Soil	2.67 – 2.90
Organic Soil	1.00 – 2.67

3.3.2 Particle Size Distribution

The synthesis of soil particles are of a mixed bag of sizes and shapes. The scope of molecule size present in the same soil test is from a couple of microns to a couple penny meters. Numerous physical properties of the dirt, for example, its quality, porousness, thickness and so on are relied on upon distinctive size and state of particles present in the dirt specimen.

Sifter examination which is ruined coarse grained soils just and the other system is sedimentation investigation utilized for fine grained soil test, are the two strategies for discovering Particle size appropriation. Both are trailed by plotting the outcomes on a semi-log diagram where ordinate is the rate better and the abscissa is the molecule distance across i.e. sifter sizes on a logarithmic scale. The strainer investigation for coarse grained soil has been directed.

Very much evaluated or inadequately reviewed are essentially the sorts of soil found. All around reviewed soils have distinctive particles of diverse size and shape in a decent sum. Then again, if soil has particles of a few sizes in overabundance and inadequacy of particles of different sizes then it is said to be ineffectively or consistently evaluated.

The outcomes from sifter investigation of the dirt when plotted on a semi-log diagram with molecule width or the strainer estimate in factory meter as the X-hub with logarithmic hub and the rate better as the Y-pivot. This semi-log diagram gives an unmistakable thought regarding the molecule size dispersion. From the assistance of this bend, D10 and D60 are steadfast. This D10 is the measurement of the dirt underneath which 10% of the dirt particles lie. The proportion of, D10 and D60 gives the consistency coefficient (Cu) which thusly is a measure of the molecule size range in the dirt example.

3.3.3 Liquid limit and Plastic Limit Test

The fluid furthest reaches of a dirt is the moistness substance or the current dampness, conveyed in rate of the mass of the oven dried soil at the breaking point composed between the fluid and plastic states. The water content at this farthest point condition is self-confidently characterized as far as possible and is the clamminess content at a consistency as controlled by technique for the standard fluid utmost mechanical get together.

As far as possible is the dampness substance comparing to the limit between fluid state and plastic conditions of soil mass. At fluid breaking point the dirt has such a low shear quality (17.6g/cc) which streams to standard measurement for a length of 12mm of a notch when jostled 25 times utilizing the standard fluid utmost gadget or device. Casagrande contraption is one of the mechanical assemblies utilized for deciding the fluid furthest reaches of a dirt material. The water content at which 25 drops of the glass to make the furrow excessively close is called as far as possible.

As far as possible is the dampness content at which the dirt stays in plastic state. It is the water content at which the dirt just starts to disintegrate when moved into a string of 3mm breadth.

Plasticity Index (P.I.) = Liquid Limit (L.L.) – Plastic Limit (P.L.)

(Source: - www.humboudmfg.com)

Figure 3.1:- Liquid limit apparatus

In one sentence the transition state from the liquid limit state to plastic limit is called liquid limit at this stage all soil posses certain small shear strength. The transmission from the plastic stated to the semisolid state is termed as plastic limit (PL).

3.3.4 Residue Test for Emulsion

This test method covers the quantitative determination of residue in emulsified asphalts composed principally of a semisolid or liquid asphaltic base, water, and an emulsifying agent.

A sample of emulsified asphalt in an open top beaker is heated in an oven at 163 ± 3°C to determine the percentage of asphalt residue. The residue from the evaporation may be tested as required. All emulsified asphalts shall be properly stirred to achieve homogeneity before testing. Determine the weight of each of three beakers containing a glass rod to 0.1 g. Weigh 50 ± 0.1 g of thoroughly mixed, emulsified asphalt into each of three beakers. Place the beakers containing the rods and sample in the oven, which has been adjusted to 163 ± 3.0°C, for 2 h. At the end of this period remove each beaker and stir the residue thoroughly. Replace in the oven for 1 h, and then remove the beakers from the oven, allowed to cool to room temperature, and weigh with the rods.

Residue, % = 2 (A - B)

Where: - A = weight of beaker, rod, residue

B = tare weight of beaker

3.3.5 Compaction Test (Modified Proctor Test)

Compaction Test is basically for determination of the relationship between the dampness substance and dry thickness of soils compacted in a mould of a given size with a 2.5 kg rammer dropped from a stature of 30 cm. It is an examination focus test framework for tentatively choosing the ideal dampness content (OMC) at which a given soil sorts will get most thick and finish its greatest dry thickness (Yd). The name Proctor is given out of thankfulness for R. R. Delegate for exhibiting that the dry thickness of soil for a comp dynamic effort depends on upon the measure of water the dirt holds all through soil compaction in 1933. His extraordinary test is most by and large insinuated as the standard Proctor compaction test, which as of late was updated to make the new compaction test. That is Modified Proctor Test.

If there should arise an occurrence of altered delegate all the methods stay same with just a couple of little changes. In particular here the compaction burden is higher. Here rammer estimate 4.5 kg and that dropped from tallness of 18 inches. For the most part these lab tests are comprises of compacting soil at perceived dampness content into a barrel shaped mold of standard estimations.

The dirt that is ordinarily compacted into the mould to a certain measure of identical layers, every one getting a number blows from a standard weighted sledge at a standard stature. This procedure is then repeated for unmistakable characteristics of substance and the dry densities are resolved for every one case. For this situation materials are filled in five identical layers with 25 blows in every one layer. The mallet and the mould for changed delegate test are demonstrated as follows.

(Source: www.testersinchina.com)

Figure 3.2:- Modified proctor apparatus

The graphical relationship of the dry thickness to dampness substance is then plotted considering the qualities found to set up the compaction bend. The decided bend comes fit as a fiddle and become thickness worth is expanding scarce to a most extreme cut off and after that again the quality diminished. The most extreme dry thickness is at last acquired from the top purpose of the compaction bend and its relating dampness content, which is known as the ideal dampness content (OMC). Utilized equations are recorded underneath.

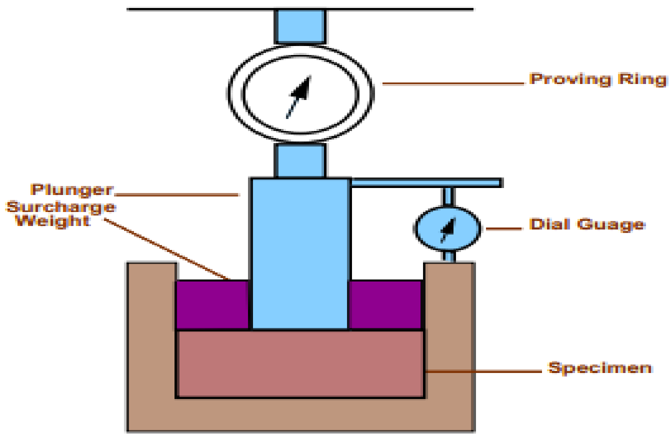
Normal wet density = (weight of wet soil in mould grams) / (volume of mould cc)

Moisture content (%) = ((weight of water grams) / (weight of dry soil grams)) 100 %

Dry density ¥$_d$ (gm/cc) = wet density / (1+ (moister content/100))

3.3.6 California Bearing Ratio Test

CBR is the extent of power for each unit district expected to enter a dirt mass with standard burden at the rate of 1.25 mm/min to that required for the following infiltration of a standard material. The going with table gives the standard burdens used for assorted infiltrations for the standard material with a CBR nature of 100%.This standard burden is taking limestone as a standard material and its CBR esteem at 2.5 mm, 5 mm, 7.5mm & 10 mm infiltration are settled as standard burden for CBR esteem determination.



(Source: www.cdeep.iitb.ac.in)

Figure 3.3:- C.B.R. test apparatus

CBR value is calculated by this formula:

C.B.R. = (Test load /Standard load) 100 %

Standard load is for particular depth of penetration of plunger is given bellow

Table 3.2: Standard load in different penetration

Penetration of plunger (mm)	Standard load (kg)
2.5	1370
5.0	2055
7.5	2630
10.0	3180

The CBR test is done on a compacted soil (by 30 blows) in a tube shaped CBR mold of 150 mm breadth and 175 mm tallness gave detachable neckline of 50 mm and a distinct punctured base plate of hard metal. A displacer plate, 50 mm significant inside the mold all through the illustrations status by which sample of 125 mm significant is obtained as genuine profundity. The dry thickness and water substance be stayed same as would be kept up all through field compaction. Overall, CBR characteristics of both doused and in un-splashed examples are resolved. Every one additional charge opened weight; 147 mm in estimation with a central whole 53 mm in separation crosswise over and measuring 2.5 kg is considered give or take equivalent to 6.5 cm of development. At least two extra charge weights are issued which are situated on the sample. Burden is associated so that the infiltration is approximately 1.25 mm/min. The heap readings are recorded at unmistakable infiltrations, 0, 0.5, 1, 1.5, 2, 2.5, 3, 3.5, 4, 4.5, 5, 5.5, 6, 6.5, 7, 8, 9, 10, 11, 12, and 12.5 mm. The most great burden and entrance is recorded if it happens for an infiltration of shy of 13 mm.

The bend is for the most part raised upwards despite the fact that the starting segment of the bend may be curved upwards because of surface inconsistencies. An adjustment is then connected by attracting a digression to the bend at the purpose of most prominent slant. The adjusted inception will be the point where the digression meets the abscissa. The CBR qualities are normally ascertained for infiltrations of 2.5 mm and 5mm. Generally the CBR values at 2.5mm entrance will be more brilliant than 5mm infiltration and in such a case the past is taken as the CBR regard for configuration purposes of a black-top structure and that is the reason CBR is a key determination of black-top thickness. If the CBR worth contrasting with an infiltration of 5mm surpasses that for 2.5mm, the test is reiterated. In case unclear results take after, the bearing proportion identifying with 5mm infiltration is taken for outline**.**

3.3.7. Unconfined Compressive Strength

The unconfined pressure test is utilized to quantify the shearing resistance of binding soils which may be undisturbed or remoulded examples. A hub burden is connected utilizing either strain-control or anxiety control condition. The unconfined compressive quality is characterized as the greatest unit anxiety acquired inside of the initial 20% strain.

To perform an unconfined pressure test, a round and hollow example of soil is arranged according to IS 4332 section v for rock i.e. test having breadth 100 mm and tallness 200 mm utilizing the U.C.S. shape in the lab. The dirt specimen is put in a stacking casing on a metal plate; by turning a wrench, the administrator raises the level of the base plate. The highest point of the dirt specimen is limited by the top plate, which is connected to a balanced demonstrating ring. As the base plate is raised, a hub burden is connected to the example. The administrator turns the wrench at a predefined rate so there is steady strain rate. The heap is slowly expanded to shear the example, and readings are taken intermittently of the power connected to the specimen and the subsequent deformity. The stacking is proceeded until the dirt builds up a conspicuous shearing plane or the disfigurements get to be extreme. The deliberate information are utilized to focus the quality of the dirt example and the anxiety strain qualities.

Figure 3.4:- U.C.S. mould and plunger

In the unconfined pressure test, we accept that no pore water is lost from the specimen amid set-up or amid the shearing procedure. An immersed example will therefore stay soaked amid the test with no adjustment in the specimen volume, water substance, or void proportion. All the more altogether, the example is held together by a viable keeping stretch that outcomes from negative pore water weights (produced by menisci shaping between particles on the specimen surface). Pore weights are not measured in an unconfined pressure test; hence, the viable anxiety is obscure. Thus, the un-depleted shear quality measured in an unconfined test is communicated regarding the aggregate anxiety. For medium grained soils U.C.S. = P / 7854 N/mm^2 = P / 78.54 Kg/ c.m.^{2}

Where P = maximum recoded load in N/ Kg

3.3.8. Durability Test

These test methods cover procedures for determining the soil-cement losses, water content changes, and volume changes (swell and shrinkage) produced by repeated wetting and drying of hardened soil-cement specimens. The specimens are compacted in a mould, before cement hydration, to maximum density at optimum water content using the compaction procedure described in Test Methods. Generally two methods are used for determining the durability of a stabilised sample. One is using ASTM D-559 and ASTM D-560 and another method is given by IRC SP-89 2010. In this study SP-89 method is used to study the durability of the stabilised sample.

Prepare two identical set (containing 3 specimens each) of UCS specimen which are cured in a normal manner at constant moisture content for 7 days. At the end of 7 days period one set is immersed in water while the other set is continued to cure at constant moisture content. When both sets are 14 days old they are tested for UCS. The strength of the set immersed in water as a percentage of the strength of set cured at constant moisture content is calculated. This index is a measure of the resistance to the effect of water on strength. If this value is lower than 80 percent it is considered that the stabilizer content is low and its value should be increased.

Chapter IV
Results and Discussions

4.1 Introduction

The experimental test was conducted on moorum with adding two additives OPC 43 grade cement and bitumen emulsion. SS-2 emulsion is used in this to study to observe the changing properties of moorum after adding the additives.

4.2 Tests conducted on Moorum

4.2.1 Basic Physical Properties

The basic physical properties of gravel (moorum) used in this study have been determined and are presented in Table 4.2.

Table 4.1: Basic Properties of Moorum

Sl. No.	Property	Test result
1	Specific gravity	2.73
2	Liquid Limit, %	30.10
3	Plastic Limit, %	21.17
4	Plasticity Index, %	8.93
5	O.M.C. %	10.12
6	M.D.D. gm/cm^3	2.02

4.2.2 Grain size distribution (sieve analysis)

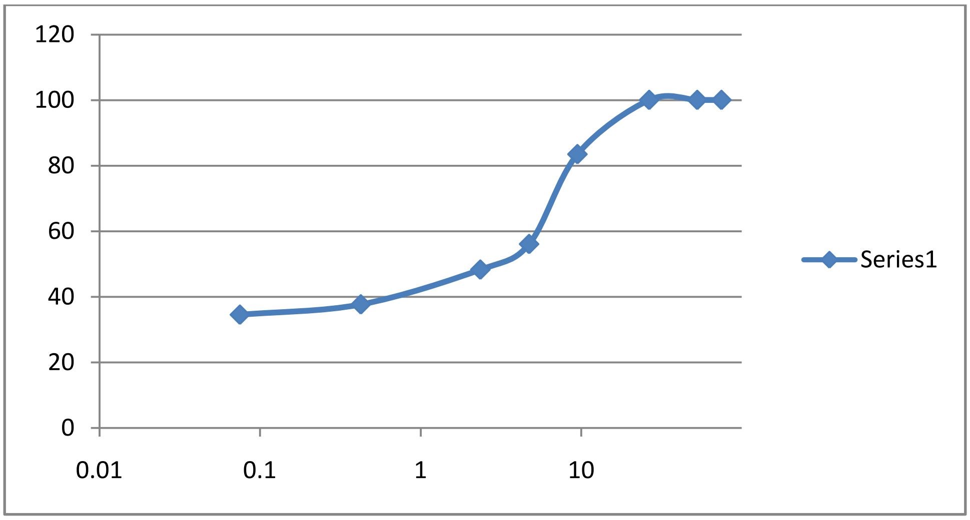


Fig 4.1: Grain size distribution graph

The gradation followed as per section 404 of "Specifications for Rural Roads" Ministry of Rural Development (first revision 2010) published by Indian Road Congress.

Table 4.2:- Gradation Followed for Moorum

IS Sieve	Percentage by weight Passing Within the Range
53.0 mm	100
37.5 mm	100
19.0 mm	100
9.5 mm	
4.75 mm	
600 micron	8 – 65
300 micron	5 – 40
75 micron	0 – 10

4.2.3 C.B.R. Test

The CBR is the measure of resistance of a material to infiltration of a standard plunger under controlled thickness and dampness conditions. This is a to a great degree typical test to appreciate the sub-level quality before development of roadways. The test has been comprehensively explored for the field association of adaptable asphalt thickness need. In a far-reaching way testing is done taking after IS: 2720 (Part 16). The test includes bringing on a round and barrel shaped plunger of 50mm distance across to enter an asphalt part material at 1.25mm/moment. The heaps, for 0.5mm, 1mm, 1.5mm, 2mm, 2.5mm… 5mm, 5.5mm, 6mm… . up to 12mm to 13 mm are recorded in every 0.5mm of expanding. Infiltration in mm are plotted in X pivot and burden communicated in kg with comparing focuses are plotted in Y hub and plan diagram for diverse example. For the most part the CBR esteem at 2.5mm infiltration is higher and this worth is adopted.CBR is characterized as the proportion of the test burden to the standard burden, communicated as rate for a given entrance of the plunger. This worth is communicated in rate. Standard heap of diverse infiltration is talked about some time.

Mould size: standard volume 2250 cc

Normal available tested soil is used for testing in this case

Used proctor test result of previous case

Maximum Dry Density value: 2.02 gm./cc

Optimum Moisture Content: 10.12%

CBR test is done for 4 days soaked condition. CBR value at 2.5mm penetration and 5mm penetration is calculated.

4 days Soaked C.B.R. value of Moorum is found to be 14.62%

Fig 4.2: C.B.R. Testing Apparatus

4.2.4 U.C.S. Test

The unconfined compression test for remoulded sample of Moorum is conducted and load applied uni-axially until failure of specimen occurs. This test provides a good assessment to the shear strength of cohesive soils. Test is conducted as IS 4332 – part (v) for gravel soils. 100 mm dia. and 200 mm height sample is prepared using the UCS mould and the sample is then tested in the UC.S. Testing machine .O.M.C. and M.D.D. data obtained in the modified proctor test are used to take the amount of soils and mount of water needed for preparing the sample.

The U.C.S. value for Moorum is found to be 0.729 kg/cm^2

Figure 4.3:- U.C.S. testing apparatus

4.3 Changes in Different Properties of Moorum after Addition of Cement

4.3.1 Change in O.M.C. and M.D.D.

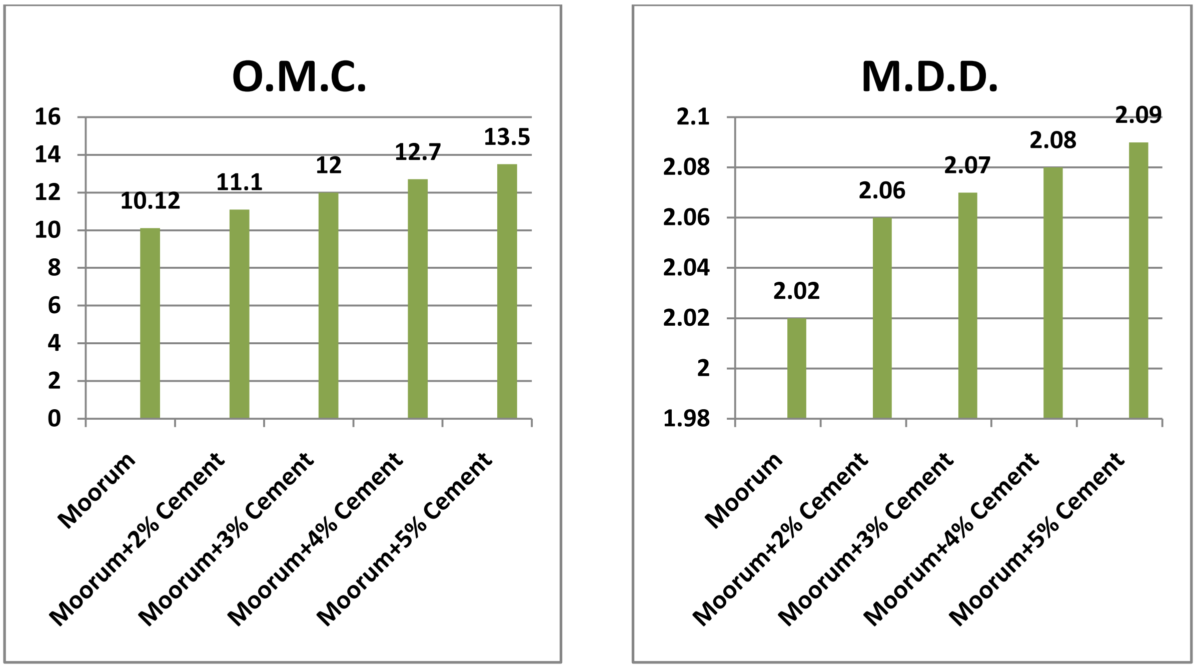


Fig 4.4: Modified proctor test comparison graph

Increase in dry density of mixes after addition of cement as compared to only Moorum is due to the stabilizing action of OPC. OPC is likely to act as pore filler as well as hydration reaction initiator. Pore filling leads to higher surface area and subsequently more moisture, and hydration itself leads to consumption of water. For these reasons, the OMC of the mix would be higher.

4.3.2 Change in C.B.R.

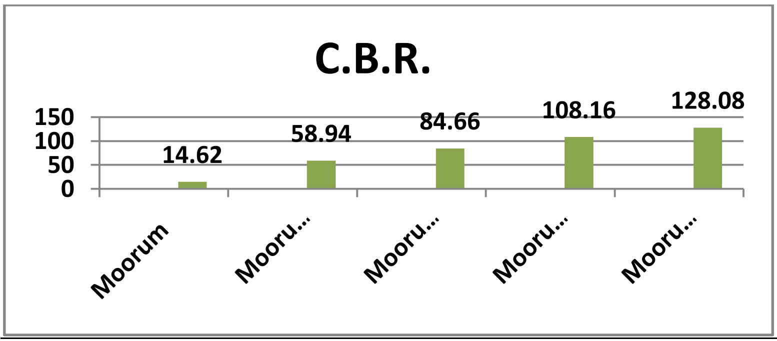


Fig 4.5: C.B.R. test comparison graph

Monotonous increase in the value of soaked C.B.R. after addition of varying % of cement. Therefore, OPC is found to be effective stabilizer for enhancing the load bearing capacity of the sub-base layer using Moorum. Pore filling and hydration reaction are cumulatively responsible for higher CBR values.

Figure 4.6 Testing of C.B.R. sample

4.3.3 Change in U.C.S.

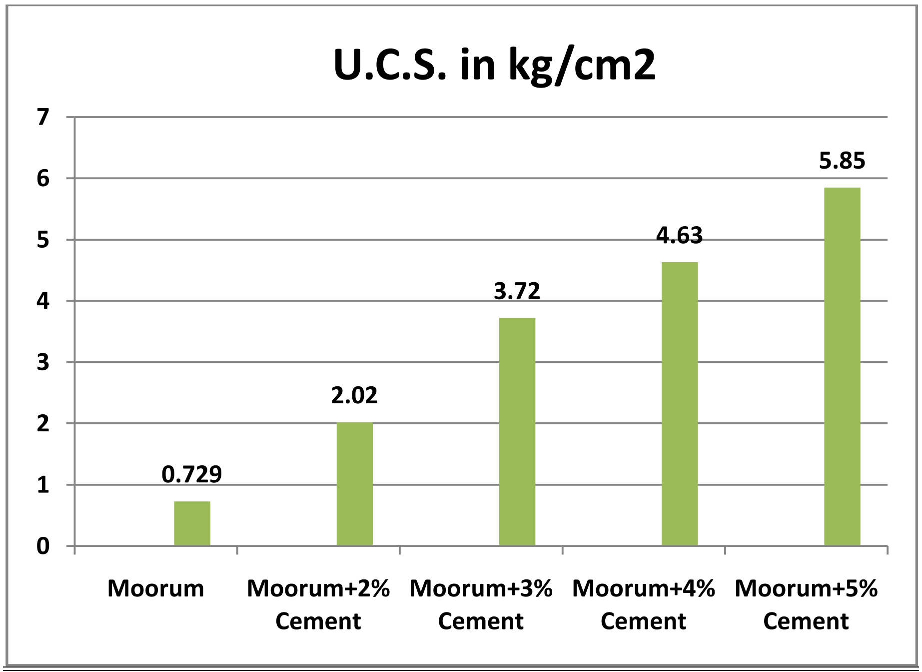


Fig 4.7: U.C.S. test comparison graph

The unconfined compression test results on remoulded samples of cement stabilized moorum are shown in above figure. Load was applied uni-axially until failure of the specimen. This test provides a good assessment of the shearing strength of cohesive soils. Its application in granular soils is somewhat limited; nevertheless, it does provide a good supplementary test as compared to other complex strength tests. The test shows that the failure cracks were generated from top of the specimen. The unconfined compressive strength increases monotonically with addition of increasing % of cement. This test has also confirmed the results of the CBR test in terms of OPC being an effective stabilizer to moorum.

Figure 4.8:- Testing of U.C.S. sample under uni-axial load

4.4 Changes in Different Properties of Moorum after Addition of Emulsion (SS-2)

4.4.1 Change in C.B.R. values with varying % of emulsion

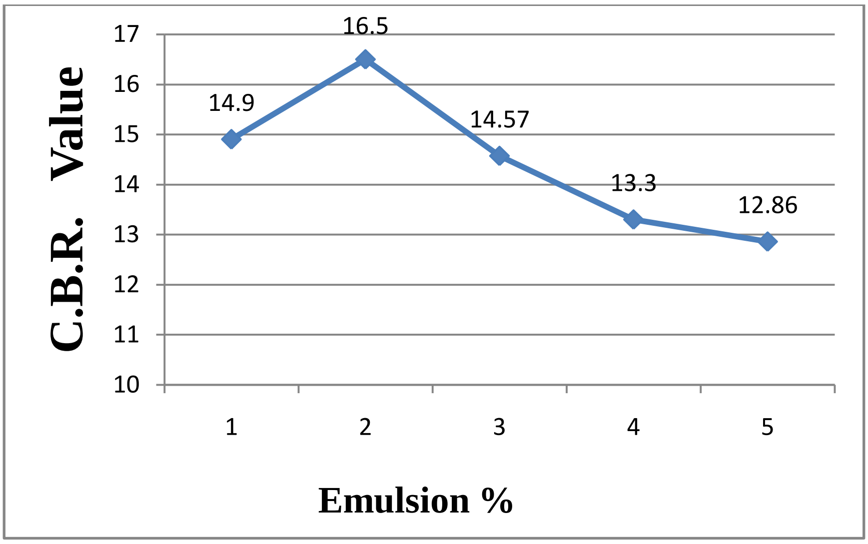


Fig 4.9:- C.B.R. Tests comparison graph

Increase in C.B.R. value with increase in emulsion percentage from 1 to 2, and then Gradual decrease in the value of C.B.R. with more percentage of emulsion. C.B.R. value at 2 % is slightly more than the C.B.R. value of normal Moorum.

4.4.2 Change in U.C.S. values with varying % of emulsion

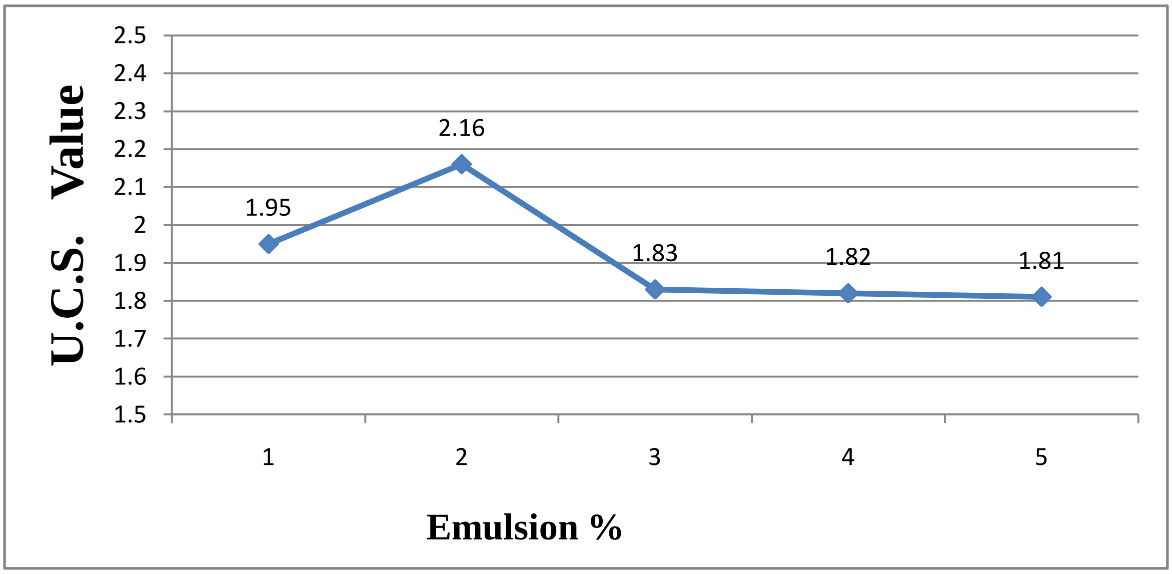


Fig 4.10: U.C.S. test comparison graph

Increase in U.C.S. value with increase in emulsion percentage from 1 to 2, and then Gradual decrease in the value of C.B.R. with more percentage of emulsion. U.C.S. value at 2 % is slightly more than the C.B.R. value of normal Moorum.

4.5 Changes in Different Properties of Moorum after Addition of Cement and Emulsion (SS-2)

4.5.1. Change in properties of Moorum after addition of 2% Cement and varying % of emulsion

4.5.1.1 Change in C.B.R.

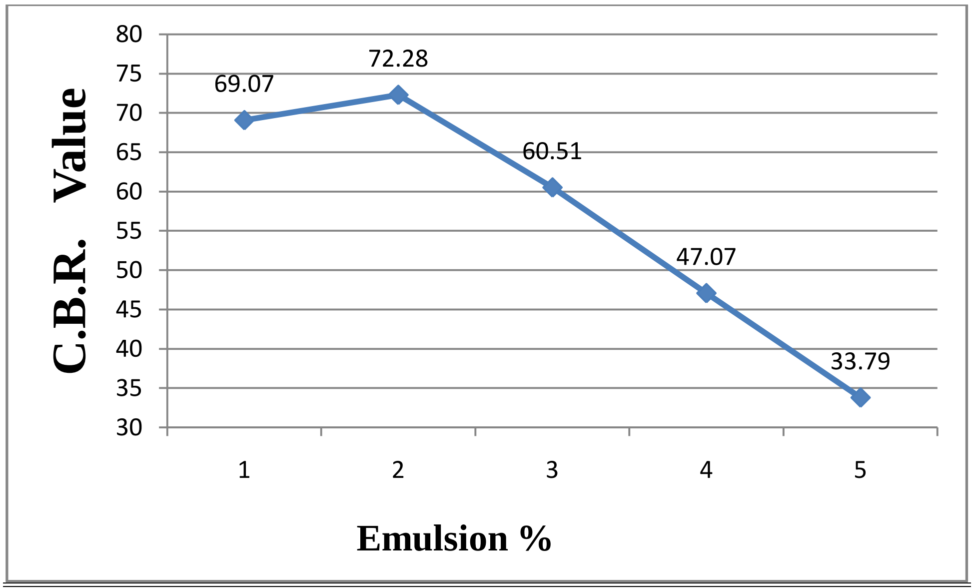


Fig 4.11: C.B.R. Test comparison graph

Increase in C.B.R. value with increase in emulsion percentage from 1 to 2, and then Gradual decrease in the value of C.B.R. with more percentage of emulsion. C.B.R. value at 2 % is slightly more than the C.B.R. value of normal Moorum with 2 % of cement.

4.5.1.2 Change in U.C.S.

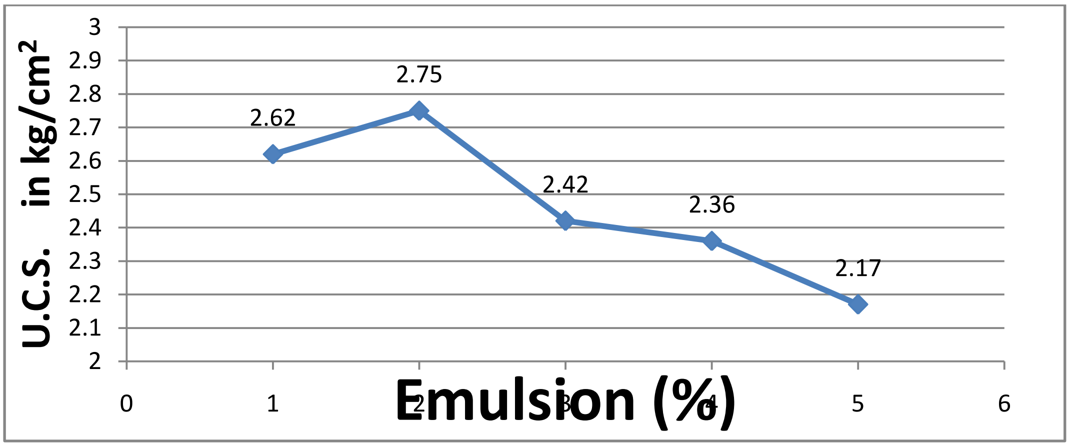


Fig 4.12: U.C.S. test comparison graph

Increase in U.C.S. value with increase in emulsion percentage from 1 to 2, and then Gradual decrease in the value of U.C.S. with more percentage of emulsion. U.C.S. value at 2 % is slightly more than the U.C.S. value of normal Moorum with 2 % of cement.

4.5.2. Change in properties of Moorum after addition of 3% Cement and varying % of emulsion

4.5.2.1 Change in C.B.R.

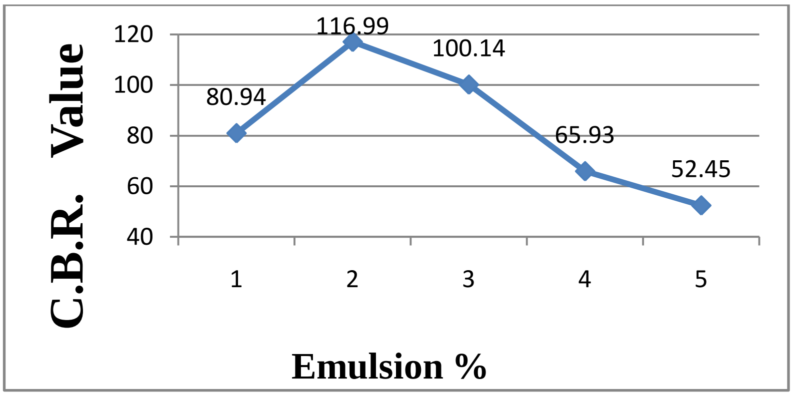


Fig 4.13: C.B.R. test comparison graph

Increase in C.B.R. value with increase in emulsion percentage from 1 to 2, and then Gradual decrease in the value of C.B.R. with more percentage of emulsion. C.B.R. value at 2 % is slightly more than the C.B.R. value of normal Moorum with 3 % of cement.

4.5.2.2 Change in U.C.S.

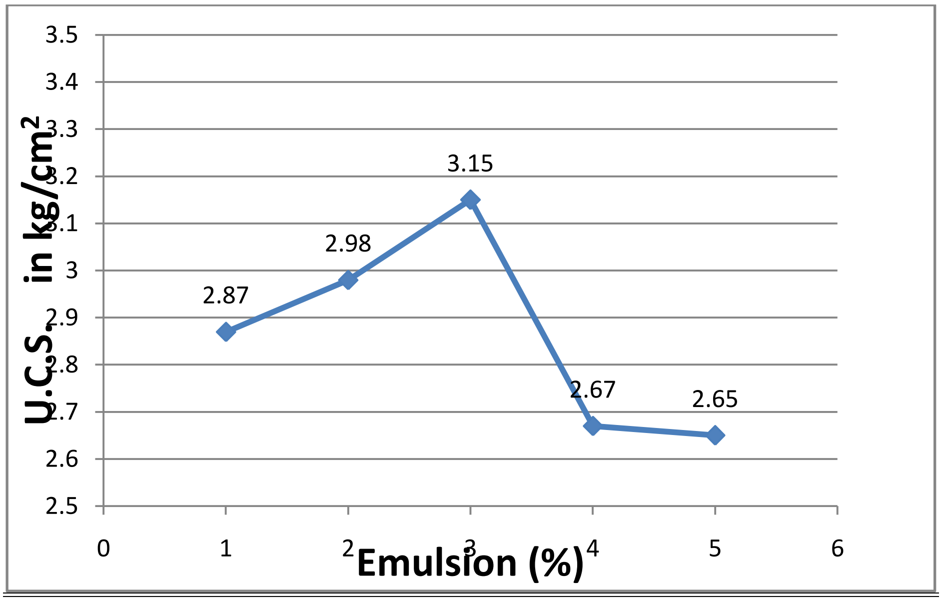


Fig 4.14: U.C.S. test comparison graph

Increase in U.C.S. value with increase in emulsion percentage from 1 to 3, and then Gradual decrease in the value of U.C.S. with more percentage of emulsion. U.C.S. value at 3 % is slightly more than the U.C.S. value of normal Moorum with 3 % of cement.

4.5.3 Change in properties of Moorum after addition of 4% Cement and varying % of emulsion

4.5.3.1 Change in C.B.R.

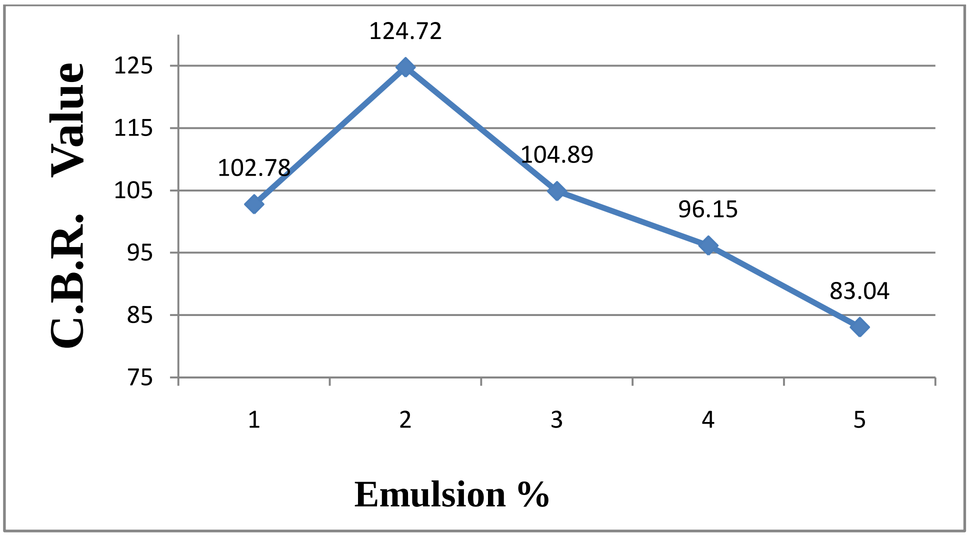


Fig 4.15: C.B.R. test comparison graph

Increase in C.B.R. value with increase in emulsion percentage from 1 to 2, and then Gradual decrease in the value of C.B.R. with more percentage of emulsion. C.B.R. value at 2 % is slightly more than the C.B.R. value of normal Moorum with 4 % of cement.

4.5.3.2 Change in U.C.S.

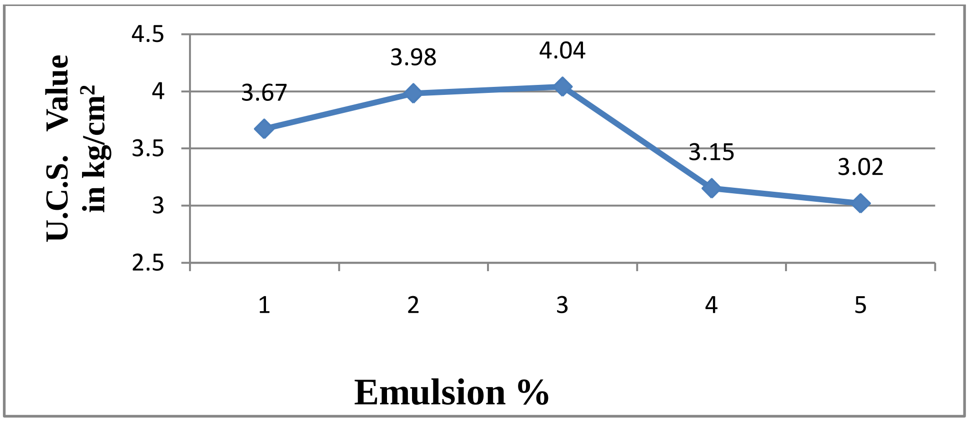


Fig 4.16: U.C.S. test comparison graph

Increase in U.C.S. value with increase in emulsion percentage from 1 to 3, and then Gradual decrease in the value of U.C.S. with more percentage of emulsion. U.C.S. value at 3 % is slightly more than the U.C.S. value of normal Moorum with 4 % of cement.

4.5.4 Change in properties of Moorum after addition of 5% Cement and varying % of emulsion

4.5.4.1 Change in C.B.R.

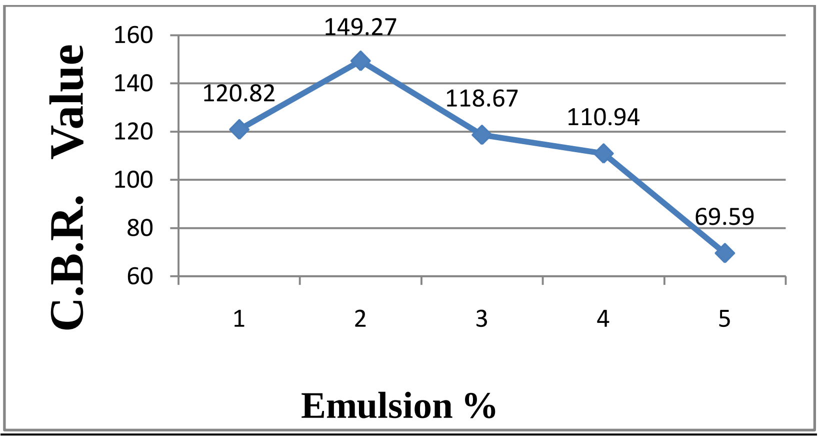


Fig 4.17: C.B.R. test comparison graph

Increase in C.B.R. value with increase in emulsion percentage from 1 to 2, and then Gradual decrease in the value of C.B.R. with more percentage of emulsion. C.B.R. value at 2 % is slightly more than the C.B.R. value of normal Moorum with 5 % of cement.

4.5.4.2 Change in U.C.S.

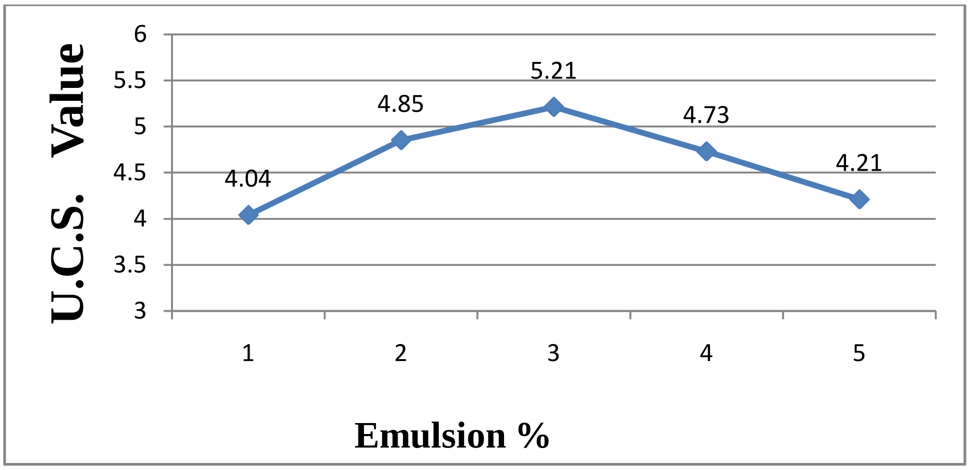


Fig 4.18: U.C.S. test comparison graph

Increase in U.C.S. value with increase in emulsion percentage from 1 to 3, and then Gradual decrease in the value of U.C.S. with more percentage of emulsion. U.C.S. value at 3 % is slightly more than the U.C.S. value of normal Moorum with 5 % of cement.

4.6 Summary from above Study

From the above study it is observed that there is considerable increase in the value of soaked C.B.R. and U.C.S. of Moorum after addition of both cement and SS-2 emulsion as stabiliser. So keeping an eye the criteria for a gravel to use in sub-base course of rural roads the best combination is chosen as Moorum with 3% cement and 2% of emulsion and subsequently durability test is conducted to check the durability of the stabilised mixture.

4.7 Durability Test

Durability test is conducted as per IRC: SP: 89 – 2010. Two identical set of UCS specimen is prepared for the best combination .One is kept in oven at 27 ± 2 degree centigrade for 14 days for normal curing after coating with paraffin to avoid any type of Moisture lost during curing period. Another one kept in oven at the same temperature for 7 days and after 7 days it was kept in water and after 14 days U.C.S. of both the samples is measured.

The result is as follows:-

UCS of specimen kept for 14 days in oven = 26.40 kg/cm^2

UCS of specimen kept for 7 days in oven and 7 days in water = 21.30 kg/cm^2

The strength of set immersed in water as a percentage of strength of set cured at constant moisture content is found to be 80.68%. This index is a measure of resistance to the effect of water on strength. As the value comes above 80% so the stabiliser % is found to be correct and hence the specimen containing this combination of stabiliser is found to be durable.

Figure 4.19:- Testing of durability sample after 14 days dry curing

Chapter V
Conclusions and Future Scope

5.1 Introduction

In this chapter the conclusions of the laboratory study carried out on Moorum for improving its strength have been summarized. The scopes and recommendation for the future research work are also discussed in this chapter.

5.2 Summary of Observations

Sub-level may be characterized as a compacted soil layer, for the most part of normally happening neighbourhood soil, thought to be 300 mm in thickness, only underneath of the asphalt hull. It gives a suitable establishment to the asphalt. So it is imperative to enhance quality of sub-evaluation soil, it might be by supplanting great soil or by adjustment of existing soil. So a study has been done to enhance the quality of Moorum by adding cement and bitumen emulsion to it to make it suitable for utilization in sub-base course of low volume roads. The accompanying conclusion has been drawn from the above studies.

Adjustment utilizing cement and bitumen emulsion builds the bearing limit of Moorum adequately. This reasons extensive increment in number of suitable proportionate standard axle load (ESAL) and therefore, the lifetime of the road will increment separately. Thus, it is clear that this kind of adjustment may be relevant in low volume road for enhancing its quality. This adjustment is able for high point of confinement of stacking in the area with absence of conventional material.

5.3 Future Scope of Works

- ✓ Analysis the strength of Moorum using any other soil test like I.T.S. or modulus of elasticity.
- ✓ Same Experiments can be performed with SS-1 or MS emulsion.
- ✓ Same experiments can be performed with adding mixture of lime and emulsion to see the variation in result.
- ✓ Same experiments can be done using cut back bitumen and cement or lime.

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